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Editorial

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Additive Manufacturing, Make Custom Porous Titanium Implant Possible

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Editorial

By late 1969, a pioneer named Branemark defined the term of osseointegration as “a direct structural and functional connection between the living bone and the surface of a load carrying implant”. He inserted submerged titanium implants with a machined surface in the jawbone of dogs. The result between the bone integration with the surface of the titanium implant gave great fixation strength. This discovery led to the development of root-form endosseous dental implants which become the standard in dentistry in the last 30 years.

Titanium and its alloys are widely used for various implants in field of dental orthopedic due to their good corrosion resistance, high osteoconductivity, and high mechanical strength. It was found that rough surfaces of titanium implants effectively promote better and faster osseointegration when compared to smooth surfaces. Nowadays, dental fabrication for dental implants is done by machining titanium rods, followed by the implant surface design modification to increase roughness by sandblasting, acid-etching, discrete calcium-phosphate crystal deposition, and chemical modification. However, Young’s modulus of (105 GPa for pure Ti) and + titanium alloys (110 GPa for Ti-6Al-4V) is about 3–10 times higher than that of bone (10–30 GPa).

This mismatch of Young’s modulus between metallic implant and the surrounding bone can cause “stress shielding” effects, which eventually lead to bone resorption specially at the implant neck area. There are many methods which have been developed to overcome stress shielding effects including; the application of porous coatings on the implant surface, such as plasma spraying, 3D fiber deposition, powder metallurgy, solid-state foaming techniques, and polymeric sponge replication. Yet, all these methods used for processing dental implants resulted in a high-density titanium structure with a micro- or nano-rough surfaces.

An alternative approach is to use implants with a macro-porous structure in order to reduce this stress shielding effects on the bone structure. Modern concepts of bone tissue engineering confirm that an open interconnected implant porous structure with pores in the range of 200–400 μm is required for bone regeneration. Using conventional techniques for implant fabrication, it was not possible to fabricate a porous titanium structure with a completely controlled design of the internal porous network as well as external shape, with mechanical strength and optimum pore size.

New technology of using cone beam computed tomography (CBCT) and 3D printing which may also called Additive manufacturing help to solve this problem. 3D printing is a direct fabrication of functional parts with complex shapes from digital models [1]. It is a group of processes that join materials to make objects from 3D model data, usually layer by layer, as opposed to subtractive manufacturing (milling) methodologies. The advantages of additive manufacturing over subtractive manufacturing are; better manufacturing a tooth with all its fine details and does not require post-processing procedures as milling. Surface contamination is considered a potential problem with traditional processing for fabrication of dental implants, since it is carried out under mineral oil refrigeration and with different materials for machining burs.

To construct custom made porous titanium implant, CBCT make 3D digital images to remaining roots of non-restorable tooth and its surrounding bone, then data transferred using STL format files (open system) to additive manufacturing part where 3D printing is made using laser sintering or electron melting to build predesigned internal and external custom made porous implant [2-5]. A high-power energy source (laser beam in laser sintering or electron beam in electron melting techniques) is focused on a metal powder bed and programmed to fuse particles in selective regions according to a CAD file, thus generating a thin metal layer. When the selective melting of one layer is completed, the building platform is lowered by predetermined distance (usually 20–100 μm) and a next layer of powder is deposited on the platform. The process is then repeated with successive layers of powder until the required part is completely built.

Immediate implant placement preserves the alveolar height and width, reducing the marginal bone resorption that is typically follows extraction socket healing. The advantages of immediate implant placement are: decrease in treatment time, avoidance of a second surgical intervention, leading to overall cost reduction and improvement in the patients’ psychological outlook for dental treatment.

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